

A STRIP OF LAMINATION SECTORS AND A METHOD OF  
MANUFACTURING A MAGNETIC CIRCUIT FOR AN ELECTRICAL  
MACHINE

The invention relates to manufacturing magnetic  
5 circuits, in particular the stator magnetic circuits of  
electrical rotary machines.

BACKGROUND OF THE INVENTION

It is known to make the magnetic circuits of  
electrical rotary machines by stacking magnetic  
10 laminations that are provided with slots.

French patent application FR-A-2 109 301 discloses a  
manufacturing method in which a strip of sectors that are  
connected to one another by narrow portions serving as  
respective hinges are wound on a mandrel. Once winding  
15 has been completed, the narrow portions lie inside the  
outside diameter of the stator and do not project  
outwards.

When the narrow portions are deformed during the  
winding operation, they tend to take up a small amount of  
20 curvature outside the plane of the sector, which tends to  
interfere with bringing the stacked sectors into face-  
against-face contact.

Japanese patent application JP 11 234 973A describes  
a yoke made up of interconnected sectors.

25 Japanese patent application JP 09 308 143A describes  
sectors each comprising merely a tooth, and  
interconnected by bridges of material.

OBJECTS AND SUMMARY OF THE INVENTION

The invention seeks to facilitate and improve the  
30 manufacture of magnetic circuits for electrical machines,  
in particular rotary machines of large dimensions in  
which the bore diameter of the stator is greater than or  
equal to 300 millimeters (mm).

The invention achieves this by a novel strip of  
35 lamination sectors for making the magnetic circuit of an  
electrical machine, in which the sectors are  
interconnected by links, the strips being designed to be

wound on a mandrel to form a stack of layers of sectors, wherein said links are outside the sectors, each sector preferably having at least one slot for passing electrical conductors.

5       The invention improves contact between the sectors of the stack since the link portions extend outside the plane of the sectors and are therefore situated outside the outside diameter of the stack.

10       In a preferred implementation, said links are constituted by bridges of deformable material or bridges obtained by being cut out together with the sectors.

      In a variant, the links are hinged links provided by staples.

15       The shape given to the above-mentioned bridges of material is selected to enable them to deform while the strip of sectors is being wound on the mandrel.

      Each of the bridges can have a portion presenting two parallel edges.

20       In a variant, each of the bridges of material can present two narrowings on either side of a middle portion, said narrowings constituting preferred zones for deformation.

      In another variant, each of the bridges of material can present concentric edges.

25       Advantageously, each bridge of material has an edge situated in line with the lateral edge or docking flank of a sector to which it is connected.

30       Advantageously, the sectors have complementary profiles on their docking flanks so as to ensure proper radial positioning of the sectors during winding.

35       These complementary profiles can include a tooth on one of the flanks and a notch on the other flank, preferably a notch of complementary shape, the tooth preferably having edges that converge and the notch having edges that diverge.

The invention also provides a method of manufacturing the magnetic circuit of an electrical machine, the method comprising the steps consisting in:

- making a strip of lamination sectors
- 5 interconnected by deformable and/or hinged links, two consecutive sectors within said strip presenting adjacent lateral edges forming an angle between each other; and
- winding the strip of sectors on a mandrel so as to move said edges towards each other and thus make up a
- 10 stack of layers of sectors, each sector being cut out in such a manner that its angular extent is different from an integer submultiple of a complete turn.

This avoids superposing the links which are thicker than the sectors and would otherwise prevent the layers

15 from touching completely.

Preferably, the length of the sectors is selected in such a manner as to limit the frequency with which junctions between sectors are superposed.

This avoids superposing breaks in the magnetic

20 circuit, thereby limiting electrical losses and providing the stack with better mechanical cohesion.

The invention makes it easy to make a magnetic circuit for an electrical machine continuously by winding the strip of sectors on a mandrel whose outside diameter

25 is greater than or equal to 300 mm, for example.

Preferably, said mandrel is rotated.

Also preferably, the angular width  $\omega$  of a sector is equal to  $360^\circ \cdot (\frac{1}{k} \pm j/n_d)$ , where  $n_d$  is the total number of slots per complete turn,  $k$  is a non-zero integer

30 submultiple of  $n_d$ , and  $j$  is an integer.

Advantageously,  $n_d$  is selected from the following values: 48; 60; 72; 84; 96,  $j$  lies in the range 1 to 3, and  $k$  is greater than or equal to 3, preferably equal to 6.

35 The invention also provides a magnetic circuit for an electrical machine, the circuit comprising a stack of

layers of sectors formed by helically winding a strip of sectors that are interconnected by deformable and/or hinged links situated peripherally, outside the stacked sectors.

5 In a particular embodiment, the bars are fixed to the periphery of the stack, being engaged in or between the deformable and/or hinged links interconnecting the sectors.

Advantageously, said deformable and/or hinged links  
10 serve as guides for fixing the bars, which bars serve to keep the layers of sectors in contact and advantageously constitute cooling channels with the case of the machine.

The fact that the links between sectors project outside the stack increases the heat exchange area in the  
15 cooling air channel around the magnetic circuit.

In addition, the discontinuous distribution of links in the air channel has the effect of making the air flow more turbulent and of increasing the heat exchange coefficient.

20 The invention also provides an electrical machine including a magnetic circuit, in particular a stator, as defined above.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood on reading  
25 the following detailed description of non-limiting implementations, and on examining the accompanying drawings, in which:

• Figure 1 is a diagram showing sectors being wound onto a mandrel that is being rotated, so as to build up a  
30 stack of magnetic laminations;

• Figure 2 is on a larger scale and shows in detail a link provided by a staple between two consecutive sectors in the strip of sectors;

• Figures 3 to 6 show various embodiments of  
35 deformable links between sectors;

• Figure 7 shows the stator of an electrical rotary machine made by implementing the method of the invention;

- Figure 8 shows a link between sectors having complementary profiles on their docking flanks; and
- Figure 9 is a diagrammatic view showing the way junctions between sectors are not directly superposed.

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## MORE DETAILED DESCRIPTION

Figure 1 shows a strip 10 of sectors 11 being wound onto a mandrel 12 that is being rotated about an axis perpendicular to the plane of the figure.

10 The outside diameter of the mandrel 12 is greater than or equal to 300 mm in the embodiment described.

The sectors 11 can be guided as they move towards the mandrel 12 by means of a chute or conveyor 13 and they come from a station (not shown) for cutting out the sectors and stapling them together.

15 Figure 2 shows two consecutive sectors 11 of the strip 10 on a larger scale, the sectors being connected together by a hinged link 20.

This hinged link 20 is constituted in this example by a staple 22 whose ends are engaged in holes formed in tabs 21 formed on the outer peripheral 16 of each sector 11, said tabs projecting outwards.

20 Slots 18 are made in the sectors 11, in the radially inner sides thereof to receive the stator windings in conventional manner.

25 In this case, the stator has 72 slots and each sector 11 has ten slots.

As a result, the junction lines between two consecutive sectors 11 are not superposed from one layer to the next in the stack, but are offset as shown in particular in Figure 9.

30 In this figure, it can be seen that the links between sectors, as represented by black strokes, are not superposed from one layer of sector to the next, but only once every five layers of sectors.

35 This prevents the links from being superposed, which would otherwise have impeded stacking the layers of sectors.

In Figure 2, it can be seen that within the strip of sectors two consecutive sectors 11 present adjacent edges or docking flanks 19 that are at an angle to each other, and the result of the operation of winding the strip on the mandrel 12 is to move the two edges 19 together so that they touch.

The sectors can be linked together by means other than staples.

In particular, it is possible to use bridges of material made by cutting out the sectors from a single piece as shown in Figures 3 to 6.

These figures show various shapes that can be given to the bridges of material uniting pairs of consecutive sectors.

In the embodiment of Figure 3, there can be seen consecutive sectors 11' interconnected by a bridge 30 of material made by being cut out together with the sectors 11' from a single piece of material.

This material bridge 30 is connected at one end to the outer peripheral edge 16' of one sector 11 and has a middle portion 31 of constant width.

The above-mentioned middle portion 31 deforms slightly away from its plane when the adjacent edges 19' of the sectors 11' are brought together during winding onto the mandrel 12.

The sectors 11' have slots 18'.

The material bridge 40 in the embodiment of Figure 4 differs from the preceding embodiment in that it has two narrowings 42 at opposite ends of a middle portion 41, thereby creating preferred deformation zones.

The material bridge 50 in the embodiment of Figure 5 has a middle portion 51 of constant width terminated radially by two concentric circular edges 53 and 54.

The middle portion 51 flares at its ends and is connected to the sectors 11' via portions 56 that extend substantially radially once the stator has been built up.

The material bridge 60 in the embodiment of Figure 6 has a middle portion 61 of constant width defined radially by two concentric circular edges 62 and 63.

5 The radius of curvature of the material bridge 60 is smaller than that described with reference to Figure 5.

In the embodiments of Figures 3 to 6, the links project outwards from the sectors, i.e. they extend outside the outside diameter of the stator and consequently they do not impede stacking.

10 By way of example, the links can extend outwards from the stator over a radial distance that is greater than or equal to one-tenth of the maximum size of a sector in the radial direction.

15 Figure 7 shows a stator magnetic circuit made up by stacking sectors 11 or 11'.

Channel section bars 70 are fixed to the outside of the stack to assemble the various layers together, to stiffen the assembly, and to constitute spacers between the magnetic circuit and the case 72 of the machine.

20 The bars 70 form cooling channels 73 between one another, the casing 72, and the magnetic circuit of the stator.

The bars 70 are shaped to engage on the links between sectors, with the links acting as guides.

25 This facilitates installing the bars 70 prior to fixing them to the stack, e.g. by welding.

It will be observed that the distribution of the links in the cooling channel between the case 72 and the stator serves to increase the heat exchange coefficient.

30 Naturally, the invention is not limited to the embodiments described above.

Means other than those described could be used for interconnecting sectors in hinged manner.

35 It is also possible, advantageously, for the docking flanks of the sectors to have complementary profiles for improving positioning in the radial direction of one

sector relative to an adjacent sector on the winding mandrel.

By way of example, Figure 8 shows two sectors 11" which differ from the sectors shown in Figure 4 merely by the fact that a tooth 70 is formed on one of the docking flanks 19" and a notch 81 of complementary shape is formed on the adjacent docking flank 19".

The tooth 80 extends along an axis perpendicular to a radius once winding has been performed, and it has converging edges 82 so as to make it easier to engage in the notch 81.